Natural Gas Brief

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Why Isn't Natural Gas in India's Climate Strategy?

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India's energy-related emissions of greenhouse gases (GHGs) are predicted to grow far more than those of any other country between now and 2040. This is a function both of India's low per capita energy consumption and GHG emissions today and its plan to continue to rely on carbon-intensive coal to supply the vast majority of its energy. The climate policy commitment that India made in advance of the 2015 Paris Climate Conference—its Intended Nationally Determined Contribution (INDC)—aims to displace significant coal with an ambitious build-out of solar energy. At the same time, India's policymakers still appear to view coal as the only energy source that can reliably support economic growth, and they target a doubling of domestic coal production by 2020.

One energy source that does not appear anywhere in India's INDC is natural gas, despite the fact that gas-fired power plants emit roughly half the CO_2 per unit energy output of coal plants. Just as importantly for India, gas-fired plants are negligible emitters of local pollutants, in contrast with coal plants, whose emissions of sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulates are a major contributor to air pollution.

Given the theoretical potential of natural gas to displace significant coal in India, why isn't the fuel highlighted in the country's climate strategy? The Indian government is not exactly ignoring gas; it has ambitious plans to grow its natural gas import infrastructure

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Dr. Thurber teaches a course on energy markets and policy in the Graduate School of Business at Stanford, in which he runs a classroom simulation of energy and carbon markets. He also oversees PESD's work on business models for distributed solar generation in sub-Saharan Africa. Dr. Thurber has experience working in the high-tech industry, with a focus on manufacturing operations in Mexico (where he lived for several years), China, and Malaysia. He holds a Ph.D. from Stanford University and a B.S.E. from Princeton University.

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over the next five years. Also, to be fair, the process of developing an INDC was a bureaucratic and politically-sensitive one in India as in most other countries, so there was likely some arbitrariness in what energy initiatives "made the cut." Nevertheless, the fact remains that gas was conspicuously not included in India's INDC, nor has it been featured since then as an important part of India's climate strategy. The goal of this brief is to identify the likely reasons why and then consider whether natural gas should receive more emphasis.

One reason to downplay gas appears obvious at first. India does not have nearly as much gas as it does coal, and gas is more expensive than coal. Relying too heavily on gas would therefore appear to put India's energy security and economic development prospects at risk. And indeed, past experience seems to show the danger of a gas strategy. India's development of the Hazira-Vijaipur-Jagdishpur (HVJ) pipeline from the western gas fields resulted in the siting of fertilizer plants, power plants, and other gas-consuming industries along the pipeline route, but shortfalls in actual gas deliveries have been a persistent problem, in some cases forcing these facilities to convert to dual fueling. Also, in a 2006 report, the Planning Commission of India expressed skepticism based on their modeling that gas could be cost-competitive with coal for power generation.

I argue that India should not be so quick to dismiss gas as an important part of its strategy for climate change mitigation (and local air quality improvement). Gas imports have the potential to be comparatively inexpensive for a long time due to the expansion of gas supply around the world, and especially in the United States and Australia. Imported coal does not always come cheap, and coal use imposes many negative externalities on India that are not being accounted for in models of energy costs. That said, there are very real institutional obstacles to large-scale substitution of gas for coal in India. Gas pricing and regulatory frameworks are simply not conducive to gas development at present. Policy reforms to improve the availability of gas in India and encourage its use in the most valuable applications (rather than the most politically-connected ones) could have an important positive effect, but they are quite challenging.

Critiquing the Energy Security Rationale for Avoiding Gas

The most obvious difference between natural gas power and the many other energy sources that appear in India's INDC—solar, wind, biomass, hydro, nuclear power, and clean coal—is that increased gas use seems to imply greater import dependence. India already imports uranium and growing quantities of coal, but the energy sources highlighted in the INDC do seem to reflect the government's preoccupation with "energy independence." (This orientation has expressed itself, for example, in India's long-time focus on developing the difficult thorium-based fuel cycle for nuclear power to take advantage of the country's large thorium resources.) As I will discuss in the next section, there is much India could do on the policy front to help expand gas supply. But even if domestic supply remains limited, there is a strong argument that LNG imports are not incompatible with "energy security."

The LNG supply market is deeper than it ever has been. According to the International Gas Union (IGU), globally traded LNG volumes reached a record high of 244.8 million tonnes in 2015, and even more importantly, Australia and the United States combined could add over 110 million tonnes per annum (MTPA) of new liquefaction capacity by 2021. (The IGU projects that India will expand its regasification capacity by around 80 MTPA in the same time period, allowing it to import more gas.) Delivered gas prices in recent months have reflected this expanded LNG supply (and the effect of a weak global economy), with prices into India below $4.50/MMBtu.

The Rapidan Group reports that the government of India is pushing power companies to take advantage of low current LNG prices by restarting gas-fired power plants that had been idled. However, this is not the same thing as encouraging new builds of gas-fired plants instead of coal ones. The latter step requires more willingness to depend on the long-term availability and affordability of gas.

The 2006 Integrated Energy Policy (IEP) report by India's Planning Commission estimated that gas would only be competitive for new power generation applications with a gas price below $4.50/MMBtu (assuming a coal price of $2.27/MMBtu).

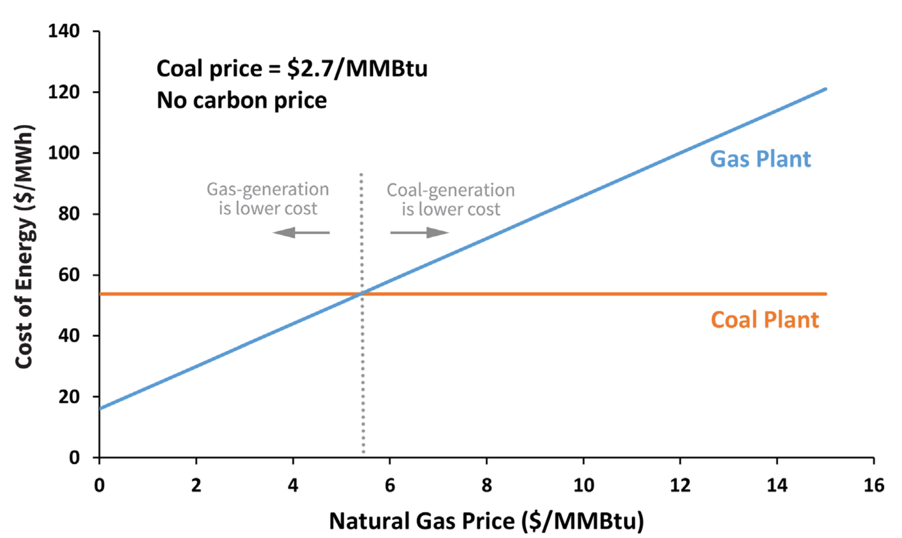

Figure 1: Electricity from gas-fired power plans is lower-cost than for coal-fired plants as long as the price of natural gas stays under $6/MMBtu.

As mentioned above, current imported gas prices into India are in fact below \$4.50/MMBtu, while current coal prices, at around \$2.70/MMBtu, are somewhat higher than the value assumed in the IEP report. At these prices, a simple levelized cost of energy (LCOE) model suggests that gas-fired generation, with its higher efficiency, is already more cost-effective than coal generation (Figure 1). On the other hand, gas prices will probably not remain so low over the long term. If we conservatively assume that coal prices stay at \$2.70/MMBtu but imported gas prices increase to \$7/MMBtu (which seems a reasonable price ceiling given expanding supplies in North America and Australia), coal plants regain their economic edge, but only as long as their negative externalities are not taken into account (Figure 2).

The incorporation of climate externalities through a carbon price of just over \$20/tonne of CO_2 is enough to bridge the economic competitiveness gap between gas and coal even at a gas price of \$7/MMBtu. The IEA predicts that developed countries are likely to see this carbon price or higher

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within the next decade or so. If the world is serious about climate change, it is likely that even India would need to see an effective carbon price of at least \$20/tonne by 2030, ideally with compensation from wealthier countries for any economic costs this imposes. Looked at in this light, the choice to build new gas rather than coal power plants is a sensible hedge against carbon policy that is almost certainly coming. In addition, while it is difficult to get reliable LCOE figures for solar developments in India, existing solar incentives probably have an implicit carbon cost of at least \$20/tonne. This suggests that a more gas-centric climate plan imposes no extra burden from an affordability standpoint. (The true cost of solar in India is a matter of vigorous debate, with solar advocates arguing that bid prices for solar parks of less than 5 Rs/kWh, or ~\$0.70/kWh, mean that solar is already economic without subsidies due to the country's favorable solar resources and low balance-of-system costs, while skeptics suggest that favorable loan terms, provision of cheap land, lack of proper accounting for the cost of grid services and thermal backup, and other incentives are contributing to the very low bid prices.)

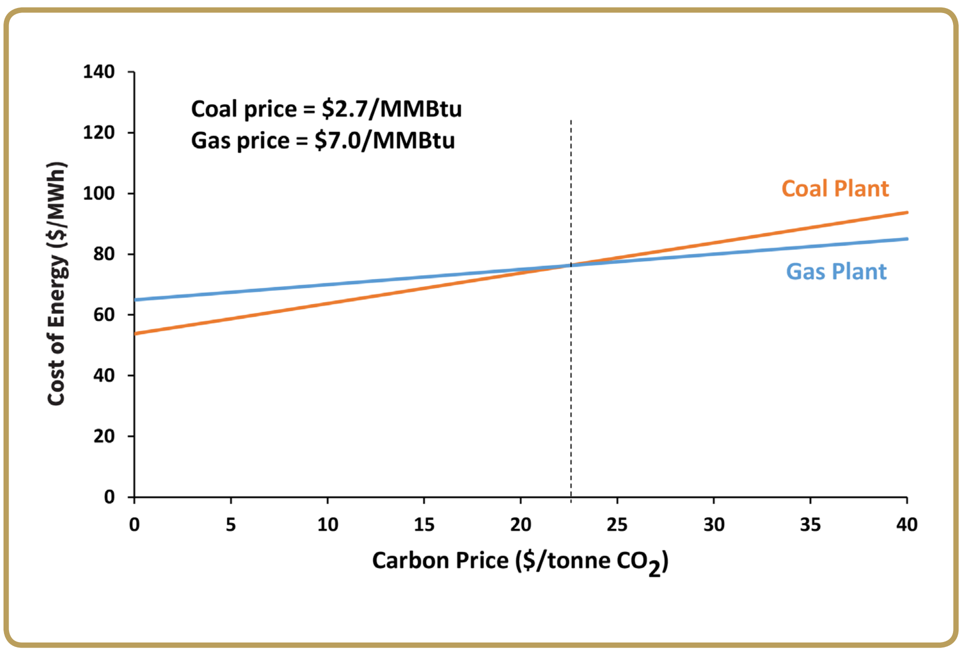

Figure 2: Effect of carbon price on economics of coal- vs. gas-fired power.

Assumptions used for LCOE model in Figures 1 and 2: Discount rate of 5%; 1,000 megawatt capacities and 40-year plant lifetimes; coal plant has \$3,000 per kilowatt (kW) overnight capital cost, 80% capacity factor, \$38 per kilowatt-year fixed operations and maintenance (O&M) cost, \$4.50 per megawatt hour (MWh) non-fuel variable O&M cost, 9,000 British thermal units (Btu) per kilowatt hour (kWh) heat rate, and 1 tonne CO_2/MWh emissions rate; and gas plant has \$1,000/kW overnight capital cost, 80% capacity factor, \$13 per kilowatt-year (kWy) fixed O&M cost, \$3.50/MWh non-fuel variable O&M cost, 7,000 Btu/kWh heat rate, and 0.5 tonne CO_2/MWh emissions rate.

Any coal-gas affordability comparison should also account for the externality of air pollution from coal. Analysis of remote sensing data by Greenpeace suggests that new coal-fired power plants with inadequate emissions controls are a major cause of the increase in SO2, NOx and particulate concentrations around major industrial clusters. The health burden of this pollution is substantial, and making natural gas the default fuel for new power plants would eliminate the incremental contribution of coal-fired power to the problem.

Does use of imported gas put India at a greater risk of supply disruptions than reliance on domestic resources? It is intuitive to equate domestic supply with energy security, but history shows that energy system disruptions most commonly result from the combination of unforeseen events, institutional failings, and lack of resiliency *inside* a country, as opposed to malign forces outside it. For example, California's electricity crisis in 2000 and 2001 was the product of serious regulatory flaws, including the split between federal and state regulatory jurisdiction, in combination with drought conditions. India's major blackouts in 2012 happened when drought conditions and associated agricultural load for irrigation exposed major problems in the robustness of the grid. When disruptions with a foreign origin have occurred, as in the case of the Russia-Ukraine gas dispute in 2009, countries with resilient markets and infrastructure have been less affected. Even the canonical example of vulnerability to foreign control over energy, the OPEC oil embargo of 1973, would have been a relative non-issue were it not for the counterproductive policy responses—namely, price controls and rationing—of oil-consuming countries like the United States.

There is no reason in theory why natural gas cannot be as energy-secure for India as coal, solar, or any other resource. The key caveat, however, is that this energy security can only be achieved with well-functioning markets and regulations in place. India has historically not had such markets for gas (or electricity), and gas shortages have been a long-time problem. The non-inclusion of gas in India's climate strategy may in part reflect this well-founded perception that gas in India has not historically been a reliable source of energy. The key question is why, and what can policymakers do to change this situation.

Rationale for Gas Pricing Reform, and Obstacles to It

Developing natural gas is fundamentally more challenging than developing oil or coal, in large part because gas transportation infrastructure (pipelines or LNG) is so expensive, requiring cost recovery over a long period of time. If gas developers do not have certainty that they can sell gas to customers at sufficiently high prices over a sufficiently long period of time, they will not develop gas fields or the infrastructure to bring gas to end customers. For the most part, India has provided neither prerequisite for gas investment, offering gas prices that are low and a pricing and regulatory framework that is highly changeable.

The Administrative Pricing Mechanism (APM) has long allocated artificially cheap gas to fertilizer producers and power plants (see Figure 3), but the low price has always caused demand to exceed supply. The New Exploration Licensing Policy (NELP), implemented in 1999, opened the upstream gas sector to private and foreign investors and promised winning bidders that they could develop gas from new exploration blocks on more favorable terms and sell it to any customers at close to market prices.

These and other reforms seemed at first to be working. India's largest gas field, Krishna Godavari KG-D6, was discovered in 2002 and started producing in 2009. However, KG-D6 production dropped off steeply within a few years, and the government intervened in pricing and forced operator Reliance Industries to allocate KG-D6 gas to favored consumers. These actions, along with government backtracking on other NELP provisions, helped discourage further private entry into India's upstream gas sector.

In 2013, the Indian government laid out a new price formula for domestic gas that would have raised prices above $8/MMBtu, with the intent once again of encouraging gas development. However, this provision was stayed before it was implemented, a victim of the change in India's government in 2014 and political pressure from the fertilizer and power sectors.

The agricultural sector is massively important in India. As a result, it has long been accepted political truth that: 1) fertilizer should be subsidized to farmers, and 2) India should be almost entirely self-sufficient in fertilizer production. If it were politically feasible to increase farm-gate prices and/or use a much larger

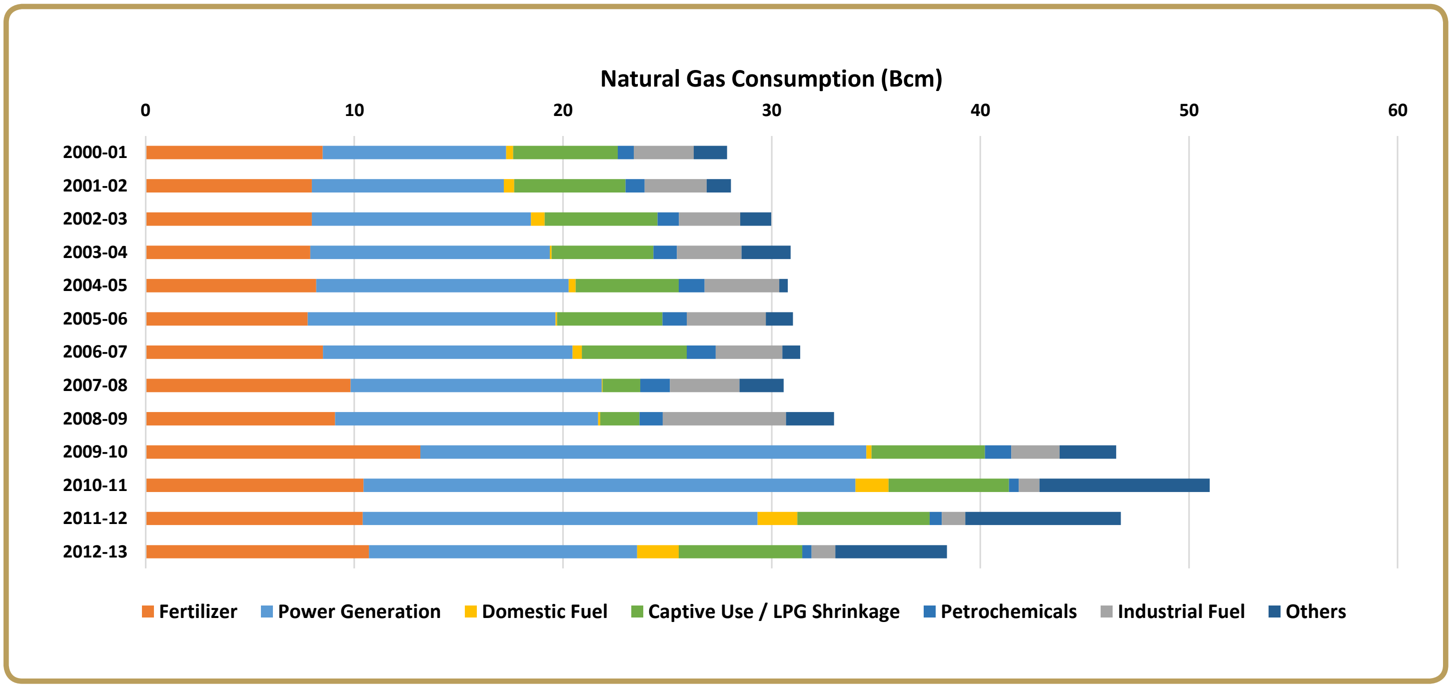

Figure 3: Gas usage by sector in India. Data source: Ministry of Statistics and Programme Implementation

share of cheaper imported fertilizer, less subsidized gas would need to be allocated to domestic fertilizer producers. As it is, the business models of these fertilizer producers depend on cheap gas feedstock, and they are incentivized to block reforms that would raise prices, even though current low prices constrict supply. (Fertilizer producers are given high priority in the allocation of subsidized gas.)

Power producers have a similar problem in that the price of their output, electricity, is frequently not sufficient to cover the price of fuel inputs purchased at market prices. The financial performance of India's State Electricity Boards (SEBs) varies greatly by state, but a number of them are heavily loss-making due to electricity tariffs that do not cover costs. Using market-priced gas in generation would make this situation worse, even though it would improve gas availability. (The inability of electric utilities to cover the cost of market-rate fuel has also caused problems in procurement of coal, especially when it is imported.)

In the face of these structural and political economy problems, it is no wonder that the Government of India struggles to make a credible commitment to rationalize gas prices, even though doing so would unlock domestic gas supply both by expanding domestic production and by redirecting gas that is used inefficiently at present. Considered in this light, India's failure to include natural gas in its climate strategy is entirely rational. Substituting gas for coal may be more cost-effective and easier to scale than solar when it comes to reducing greenhouse gas emissions, but the political and institutional difficulties in switching to gas might be substantial. Solar parks, by contrast, are easier to institutionally isolate from the other challenges in India's electricity and fossil fuels sectors.

Solar has the additional benefit that it is extremely popular among members of the public (not to mention solar developers). Global public opinion surveys across countries including India show that wind and solar are consistently viewed more favorably by respondents than fossil fuels or nuclear energy. In the run-up to the Paris Climate Conference, India faced a chorus of international disapproval over its plans to expand coal production and use, but the ambitious solar plans in its INDC proved highly effective at muting this criticism, even while the basic dependence on coal remained in place.

Broader penetration of gas-fired power in India is unlikely to be achieved until electricity and agricultural markets are reformed so that power and fertilizer producers can no longer claim so much gas at subsidized prices.

If coal is the cheapest and easiest way to provide energy when climate and air pollution impacts are *not* taken into account, renewable energy is arguably the easiest low-carbon option to sell to the public and incentivize through subsidies whose true costs are hidden. Gas requires a policy commitment to sound and transparent energy pricing, including the incorporation of a carbon price, and nuclear faces the most uphill struggle for public acceptance of any major energy source. As a result, the seemingly paradoxical "German model" of coal plus renewables can turn into the path of least resistance for India and other countries, even though more cost-effective emissions reductions could be achieved with a larger role for gas.

Conclusion: Pathways to a Gas-Friendlier India

The key to further development of gas as a replacement for coal in India may be the development of gas projects that are by their nature isolated from the broader institutional problems of the gas and electricity markets. India planned to build a number of coastal Ultra Mega Power Projects (UMPPs) that would run on imported coal. While only a few have been successfully commissioned, such as Tata Power's Mundra plant in Gujarat, the same approach could be intriguing for natural gas. One of the more forward-looking, institutionally-sound states in India could develop a large combined-cycle gas turbine power plant simultaneously with a fairly small regasification facility that would serve the power plant itself as well as industrial, commercial, and residential customers in the immediate neighborhood. In an ideal scenario, the plant would not be connected by pipeline to other major demand centers in India to avoid becoming embroiled in disputes about how gas would be allocated.

Broader penetration of gas-fired power in India is unlikely to be achieved until electricity and agricultural markets are reformed so that power and fertilizer producers can no longer claim so much gas at subsidized prices. Given India's long legacy of central planning, these reforms will not be easy. Over the longer term, however, the negative consequences of the status quo may spur policymakers to tackle them.

On the one hand, these institutional challenges make the non-inclusion of natural gas in India's climate plan completely understandable. On the other hand, the failure to include natural gas has yielded an INDC that is characterized by wishful thinking, most notably in its expectation that solar will be able to do all the heavy lifting on greenhouse gas mitigation in India. Solar may be politically and institutionally easier than gas, but it seems unlikely that it can be as cost-effective when it comes to replacing to baseload coal at scale. Gas should appear in India's climate strategy for this reason, and as a reminder of how important it is to resolve the institutional problems that have bedeviled gas markets in India thus far.

The Natural Gas Initiative at Stanford

Major advances in natural gas production have fundamentally changed the energy outlook in the United States and much of the world. A decade ago in the U.S., natural gas supplies were declining, liquefied natural gas (LNG) import terminals were expanding, and the heavy reliance on coal for electrical power generation seemed impenetrable. The revolution in natural gas production has thrust this resource into the global spotlight as a potential bridge to a cleaner energy future. This development has raised hopes, along with concerns and complex questions about global energy, the world economy, and the environment.

Stanford faculty, students, and researchers are world-renowned experts in research and discovery related to energy resources, with a particular focus on producing resources efficiently and with as few negative consequences as possible. No one is better positioned to address the complex global questions surrounding the development and utilization of natural gas in a climate-constrained and increasingly energy-intensive world.

The new **Natural Gas Initiative (NGI)** at Stanford, hosted by the School of Earth, Energy & Environmental Sciences and the Precourt Institute for Energy, will engage faculty across the university to carry out the many types of research needed to ensure that natural gas is developed and used in ways that are economically, environmentally, and societally optimal. In the context of Stanford's innovative and entrepreneurial culture, the initiative will support, improve, and extend the university's ongoing efforts related to energy and the environment.

JOIN NGI

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